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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of:)	
William A. Cook et al.)	Before the Examiner
Serial No. 542,590)	M. Shein
Filed October 17, 1983)	Group Art Unit 335
EXERCISE RESPONSIVE CARDIAC PACEMAKER)	June 13, 1985

RULE 132 DECLARATION

Hon. Commissioner of Patents and Trademarks

Washington, D. C. 20231

Sir:

I, Dr. Neal E. Fearnot, an inventor and applicant in the above-identified patent application, hereby declare:

I am an Associate Research Scholar in the Biomedical Engineering Center at Purdue University and the President of Medical Engineering and Development Institute in West Lafayette, Indiana. I received the B.S., M.S. and Ph.D. degrees in electrical engineering from Purdue University. I am a member of the Institute of Electrical and Electronic Engineers and hold two U.S. patents. I have been active for four years in pacemaker design, with a particular emphasis on exercise-responsive pacemakers, and have authored or co-authored a number of journal articles relating to this work, and have been an invited speaker at national and international scientific meetings on pacing.

I have carefully reviewed and considered the rejections made during the prosecution of the above-identified application, including in particular the final rejection of claims 10-14 for asserted obviousness

over German Patent No. 2,609,365 of Csapo. I discussed this rejection and the Csapo reference with Examiner Shein in a personal interview at the Patent and Trademark Office, and after that interview I again reviewed and considered the rejection in light of the Csapo reference. I concluded from my first review, and remain convinced after subsequent consideration, that a number of important structural differences between the catheter shown in Csapo and the catheter of the present invention defined by pending claims 10, 13 and 14 make the presently claimed device a superior catheter-based sensor/stimulator for an exercise-responsive pacemaker.

The protective structure in the catheter of claim 10 and the claims depending therefrom is an important aspect of the invention as defined by those claims. Csapo uses only single-wire leads to a thermistor and does not disclose any method for protecting the thermistor or its leads from the flexing that occurs in the catheter due to movement within the heart. Csapo states that the lead cables and electrodes require highly flexible materials. Some flexibility in the catheter is desirable, but not at the interfaces between the thermistor and its leads and between the thermistor leads and any external wires joining the thermistor to the pacemaker. Indeed, in these areas it is critical to maintain rigidity to adequately protect the thermistor from catheter flexure caused by heart movement. Our fluoroscopic videotapes show clearly that the catheter is flexed in these areas by each heartbeat. For this reason, the thermistor of the presently claimed combination and its leads are encased in epoxy and received in the lumen of a tubing portion which

is at least partially filled with an elastomer to prevent relative movement and fluid leakage. The thermistor leads are joined through two rigid conductive tubing sections to bifilar wound coil lead wires for electrical connection to the pulse generator. The rigid tubing sections bonded to and imbedded in epoxy provide strain relief between the bifilar lead wires and the thermistor leads, and the overall structure around the thermistor protects the thermistor from breakage due to flexure.

The elastomer-coated epoxy around the thermistor serves a second purpose: It reduces the migration of ions from the blood into the thermistor, which ions have been found to cause failures in long-term-implanted thermistors through substantial drift in thermistor resistance over time. In the preferred embodiment, ion migration effects have been further reduced by the use of a suitable thermistor such as Fenwall Electronics type GA51J1, a bead thermistor coated with glass. The structure of the claimed catheter not only protects the thermistor leads from breakage but also prevents flexure between those leads and the glass coating around the thermistor bead, which flexure can crack the glass coating. Breakage of the protective coating around the thermistor results in ion migration into the oxides of the thermistor, thereby causing the drift problems referred to above.

In a pacemaker which detects exercise as a function of intracardiac temperature, responsiveness to exercise is significantly improved by the use of a catheter with a thermistor mounted in a location where it will be centrally positioned within the right ventricle of the heart when the catheter is implanted, as compared with a

catheter having some other thermistor mounting location. The optimum location for a ventricular pacing electrode is in the apex of the ventricle, in which area the pacing electrode rests in the trabeculae of the endocardium, the inner wall of the myocardium. A catheter-based sensor with a thermistor mounted at the distal tip of the catheter immediately adjacent to a pacing electrode, such as that shown by Csapo, cannot provide accurate measurements of blood temperature in the heart because of insufficient blood flow through the trabeculae in the apex of the ventricle. Instead, such a sensor would simply measure the temperature of the apical myocardium. The problem is compounded by tissue growth around the catheter tip: The tissue surrounds the tip and thereby further inhibits the flow of blood around the thermistor. Although some tissue growth may occur around the catheter of the invention described by claims 10 and the claims depending therefrom, the location of the thermistor substantially proximal to the catheter tip in the central right ventricle will still allow measurement of blood temperature rather than merely endocardial temperature.

At any instant in time during a transition between states of rest and exercise, I would predict, based upon the research in which I am involved and upon principles of physiology, that there would be a significant difference between temperature variations measured centrally in the ventricle and variations in the endocardial temperature. The expected difference is a delay in response time. Heat in the central venous blood returning from hyperthermic musculature is conducted from the blood to the endocardium. A thermistor buried deep in the ventricular

apex among the trabeculae will detect a temperature rise as heat is conducted from the blood, but after some delay which is a function of the heat conduction characteristics of the blood, fibrous encapsulation and endocardium, and of greatly reduced blood flow through the trabeculae relative to the flow through the central portions of the heart chambers.

In my opinion, this delay in response would degrade the ability of a pacemaker to positively detect exercise, either by failing to detect a particular form of exercise or by falsely detecting exercise during an activity having temperature effects resembling those of some form of exercise. As a result, for some forms of exercise, I would expect a pacemaker subject to this delay not to respond quickly enough to the body's need for increased cardiac output due to muscular exertion. Csapo's pacemaker is subject to the delay described above and, in my opinion, would not operate satisfactorily in the presence of some physiologic events related to exercise.

Csapo clearly had the motivation to place a temperature sensor in a proper location to measure central blood temperature. One of the stated aims of his invention was to use that temperature for control of pacemaker frequency. Nevertheless, he chose to position the thermistor at the distal tip of the catheter, where the temperature measured is endocardial temperature.

A structure which protects the thermistor mechanically and chemically is critical to the successful long-term use of a catheter-based temperature sensor in cardiac care. Several years of our research studying the critical elements of a long-term-implanted thermistor catheter have

been required to reach this state of knowledge. The presently claimed catheter structure protects the thermistor and thereby enhances the overall integrity of the catheter. A further significant improvement is achieved by centrally positioning the thermistor within the right ventricle of the heart to measure the temperature of flowing blood as opposed to endocardial temperature. The structure of Csapo has neither of these features. Although Csapo's catheter is structurally similar to the presently claimed catheter, the absence of the elements referenced above makes his catheter unsuitable for long-term performance in an exercise-responsive pacemaker.

In my opinion, therefore, the catheter-based sensor and stimulus means of pending claim 10 would not have been obvious, in view of Csapo, to any person having my knowledge or experience in this area.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.

June 13, 1985
Date

Neal E. Fearnot, Ph.D., P.E.
Dr. Neal E. Fearnot